

# THE SIXTH GENERATION ROBOT IN SPACE

A. Butcher, A.Das, Y.V.Reddy & H.Singh

Artificial Intelligence Laboratory  
Dept.of Statistics & Computer Science  
West Virginia University  
Morgantown, W.V. 26506

## Abstract

The knowledge based simulator developed in the artificial intelligence laboratory at the West Virginia University has become a working test bed for experimenting with intelligent reasoning architectures. With this simulator, recently, small experiments have been done by the authors' group with an aim to simulate robot behavior to avoid colliding paths. An automatic extension of such experiments to intelligently planning robots in space demands advanced reasoning architectures. This paper explores one such architecture for general purpose problem solving. The robot, seen as a knowledge base machine, goes via predesigned abstraction mechanism for problem understanding and response generation. The three phases in one such abstraction scheme are : (i) abstraction for representation, (ii) abstraction for evaluation, and (iii) abstraction for resolution. Such abstractions require multimodality. This multimodality requires the use of intensional variables to deal with beliefs in the system. Abstraction mechanisms help in synthesizing possible propagating lattices for such beliefs. The machine controller enters into a sixth generation paradigm.

## 1. INTRODUCTION

" All new technologies develop within the background of a tacit understanding of human nature of human work. The use of technology in turn leads to fundamental changes in what we do, and ultimately to what is to be human. We encounter the deep questions of design when we recognize that in designing tools we are designing ways of being. By confronting these questions directly, we can develop a new background for understanding computer technology --- one that can lead to important advances in the design and use of computer systems." This is a quotation from Winograd and Flores (6).

The already announced program for the sixth generation world of computation (4) actually touches the basic content of the above equation. In one form of expression (3), the sixth generation computational activities of the next few years explores learning and emotion, parallel knowledge systems, audio and visual sensors with multimodal modeling. In this game, part of the supporting hardware is optical storage and logic, organic processor elements and routine engineering and maintenance of full-sized knowledge based systems.

This paper attempts to project views on a sixth generation robot. The robot is intelligent to generate plans and take actions independently. The original idea comes from some

computational attempt made in this school's artificial intelligence laboratory to simulate robot behavior while avoiding colliding paths. The programming environment is a knowledge based simulation system developed earlier (1). In this system of knowledge based simulation frames have been used to represent objects and their relationships, and rules to represent procedural behaviors of objects. Model making in this system becomes explicit, understandable, modifiable and self-explanatory. By using a frame language to represent domain concepts such as object structure and goals, there is a one-to-one correspondance between the domain and the simulation model. Also, by using rules to represent behavior, the specification and modification of the behavior become easier. Explanation generation techniques developed around the rule based system provide basis for explaining event behaviors. Recently, in the artificial intelligence laboratory of in this school attempts are being made to understand the process of encoding objects in frames side by side in terms of intensional and extensional variables. The extensional approach is not new. It is also known as rule based, procedure based or production systems. The well-known predicate calculus logic works here strongly. The other system, the intensional system is just the opposite. Here, non-predicate calculus logic enters automatically. We deal with *possible worlds*. Objects in frame carry *beliefs* as has been suggested for the sixth generation computations. They arise because of uncertainties present in the computation. It is well-known that intensional systems are semantically clear but computationally clumsy. It is proposed that for a smart robot capable of intelligent decision making and plan generation, intensional approach is worth attempting. In the following sections very briefly is described how the world appears in the eye of one such sixth generation robot. Also, this robot's smooth living with intelligent decision making and plan generation is aided by a three-phase abstraction hierarchy process. And, explanations have been provided on how such abstractions help the robot in simulating its actions in an uncertain world full of *plausibility*.

## 2.THE WORLD IN THE EYE OF THE ROBOT

To the robot, the world is always in a particular state at a particular time. A series of such states will appear as history. The robot is capable of witnessing and recording such world states. The robot's knowledge base classifies history in the following form:

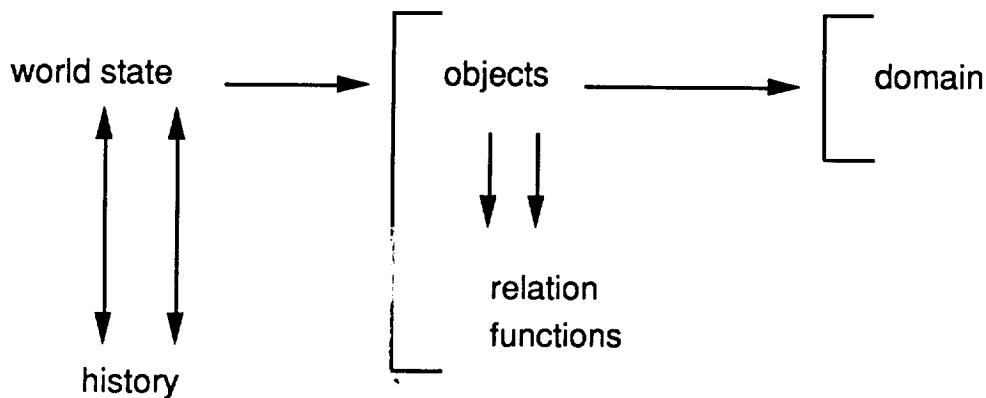
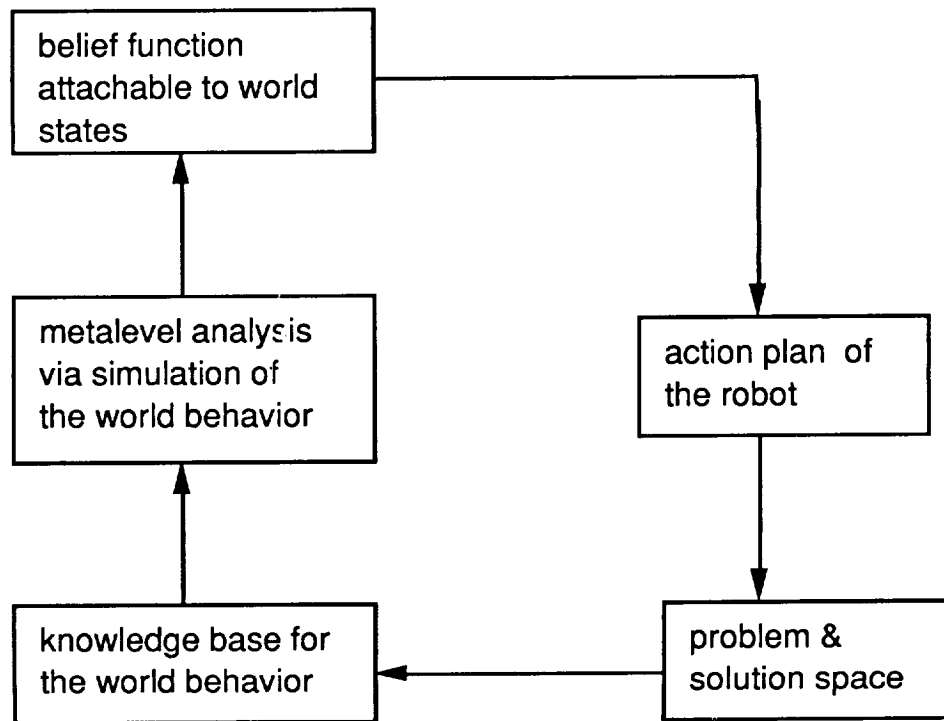


Fig.1

The world identifies a particular world state (s) by an event (e). This identification is characterized by a belief function which has a well-maintained architecture of propagation. For example, let there be two belief functions Z1 and Z2 characterizing two world states W and s. If Z1 is true when event occurs, then Z2 will be true in the resulting states. That is,

$$\bigvee W, S.Z1(s) \wedge OCCURS(e)(s) \supset Z2(SUCC(s))$$

In the present case, belief functions Z1 and Z2 are actually characteristics of predefined metalevel analysis before indexing a world state by a belief function. The overall architecture is as follows:

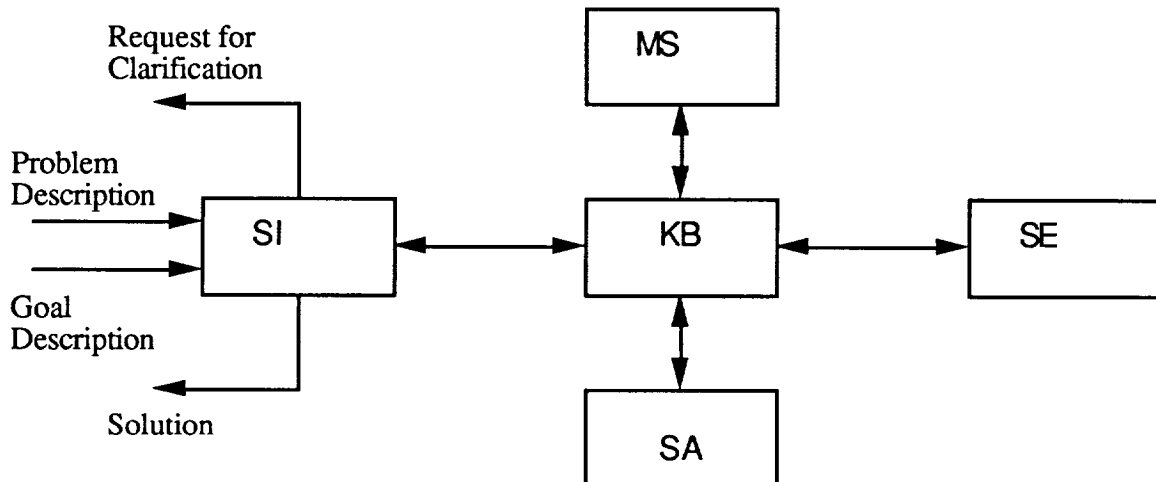


**Fig . 2**

The present author's group has implemented a substantial amount of work on the metalevel analysis via simulation of the world behavior. The work is being implemented in an object oriented knowledge based system high-lighting encapsulation and inheritance (5). Problem formulation, model building, data acquisition, model translation, verification, experiment planning, analysis of result ---- all have been treated in the program with an aim to bring a closed world subject to the domain of an open world reasoning process. Figure 3 describes the implemented knowledge based simulation environment (1).

In the simulation environment described in figure 3, the user will describe the system he or she wishes to model as well as the results he expects from the simulation interface (SI). The interface will translate this description into a representation used internally. The

representation will also indicate what results to measure while the model is executed as well as which of these results to display graphically. The model synthesizer (MS) will interpret



KB : Knowledge Base  
 MS : Model Synthesizer  
 SA : Simulation Analyzer  
 SE : Simulation Engine  
 SI : Simulation

**Fig.3**

the scenario representation into the simulation target language and build a simulation model. Once the simulation engine (SE) has executed the model, the model analyzer will translate the results of the simulation back into the representation of the results to determine if the goals have been satisfied. If they have, then the simulation analyzer reports back to the simulation interface, which in turn, translates the results to the user. If the goal has not been satisfied, then the simulation analyzer will make modifications to the model by creating one or more scenarios. This process continues until the desired goals are met or some time limit has reached.

### **3. THREE PHASES IN ABSTRACTION HIERARCHY**

To survive in one such aforementioned world of events and states, the robot needs a good planning mechanism. Such mechanisms are supported by a strong program in the science and craft of knowledge base development. It has been sketched below.

To create a knowledge base appropriate discipline needs to be followed that preserves consistency. Obviously, knowledge will come from distributed sources. Retrieval and modification thus become complex. Encoding facts, beliefs and relationships with structured learning should be generated too. Any action, taken by the robot, then is done from a flexible and accessible repository of the shared knowledge of various participants. In order to achieve this, an architecture of the three-phase abstraction process hierarchy will be narrated now. These three hierarchies are : representation, evaluation and resolution.

### Phase-1:Representation

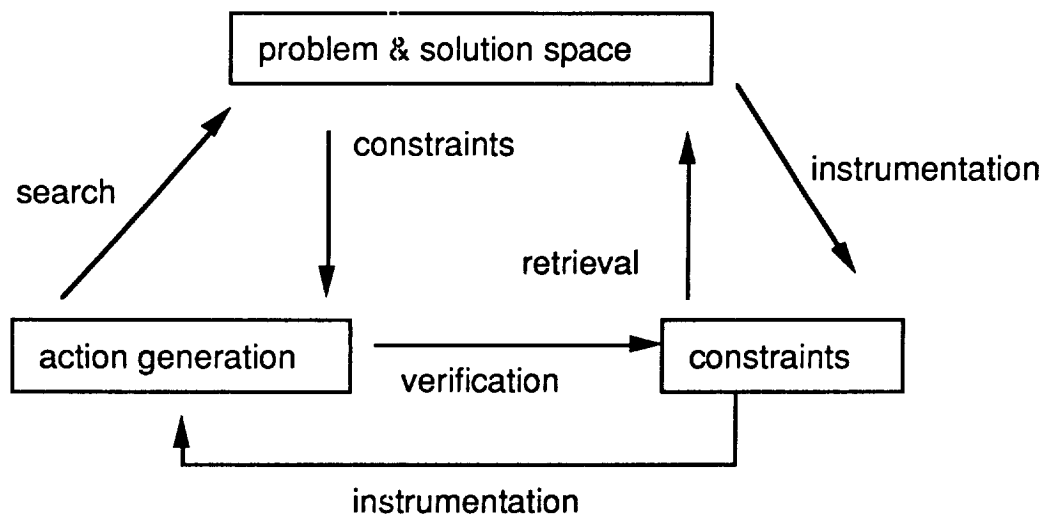
The robot is essentially a knowledge base machine. Knowledge acquisition for such a machine is very difficult. A very stringently tested policy must, therefore, be guaranteed for this. In this phase-1 level, the robot is able to generate a series of reasoning process. This is based upon an automatic problem recognition and model based approach to the solution of the problem. In the current system, for knowledge representation, a network of schema representation language is used. This represents the physical/abstract entities of the system to be modeled. Past research in this laboratory showed that, this representation scheme provides a good simulation environment in addition to simulation. The robot is waived of maintaining multiple models which eliminates extra cost.

### Phase-2:Evaluation

Before adventing any action, the robot needs an assessment of possible alternative items of their relative applicability. This has been facilitated mostly because of the use of object oriented approach to model representation. Here, objects have one-to-one correspondance with domain entities and they have methods explaining their behavior. This has provided flexibility in creating and altering entities and their behavior without altering the simulation model interpreter.

### Phase-3:Resolution

In this abstraction, the robot is trying to design the most appropriate action under certain specified goals and constraints. The specification on constraints is achieved by simulation. One possible architecture is shown in figure 4.



**Fig.4**

The above phase-3 architecture simulates a strong knowledge system support for intelligent plan generation by robots.

The three steps in abstraction helps in updating and revision of belief which is necessary to strengthen evidential support. This establishes a strong goal directed reasoning mechanism for the knowledge based system.

#### **4.CONCLUSION**

The whole environment of knowledge based simulation comprises of a sequence of experiments, where, each experiment measures how well a scenario (i.e., altered version of an original model) optimizes one or more goals. The purpose of introducing a three phase abstraction scheme is to let the robot justify, rectify, analyze, assemble its own beliefs before planning an action leading to a goal. This attitude is expected from a sixth generation robot. It, while taking actions, begins simulations first with the specification of a set of goals which result in the instrumentation of a scenario in order to gather data. Uncertainties in data are dealt with intensional mechanism, with beliefs as constraints on the simulation trajectory. Currently, we are in search of effective instrumentations to manage these constraints appropriately.

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